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A sustainable technique to applying bio-fertilizers on wheat for enhancing growth and productivity

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Abstract

In order to learn how various bio-fertilizers affect wheat growth and yield while still being environmentally friendly, this research is being reviewed. Azotobacter, Azospirillum, Rhizobium, and Phosphate Solubilising Bacteria are among the many economically significant bio-fertilizers. When combined with a few minor amendments, these bio-fertilizers cause a dramatic rise in wheat's stature, dry matter accumulation, spike number, grain density per spike, and root and shoot length. Soil fertility and health are both improved in a sustainable way by these bio-fertilizers, which benefit plant growth as well. The use of bio-fertilizers decreases the requirement for chemical fertilisers, as a result. Soil health can be maintained with the help of readily accessible bio-fertilizers, which only need a minimal amount. Increased populations of helpful microbes are a result of using bio-fertilizers. The study's findings suggest that bio-fertilizers can effectively replace chemical fertilisers, leading to increased yields in a more sustainable way that doesn't harm soil or people.

Keywords: Bio-fertilizes, Wheat, Effects, Yield, Microorganism

Introduction

A bio-fertilizer is a substance that contains live microbes that, when added to soil, live in the rhizosphere and boost plant growth by elevating the status of vital nutrients (Vessey 2003) [52]. To increase crop yields while preserving soil fertility, bio-fertilizers are an essential part of sustainable agriculture (Narula *et al.*, 2005) [32]. Chemical fertilisers were the first tool used to boost growth and output in the last century. The detrimental impacts of these fertilisers on the soil, however, become more apparent with the passage of time. Abd El Humid and Amal (1994) and Abd El-Ghany and Bouthaina (1994) [2] indicate that bio-fertilizers are currently receiving the majority of the focus for sustainable yield production. Because they are effective, cheap, and safe for the environment, bio-fertilizers are gaining importance daily (Kachroo and Razdan 2006). El-Borollosy *et al.* (2000) [16] noted that developing nations have been encouraged to utilise bio-fertilizers in an effort to reduce production costs and curb the overuse of chemical fertilisers. In addition to reducing the dosage of chemical fertilisers, biofertilizers are less expensive, safer for the environment, and show great promise for supplying plants with vital nutrients. Incorporating biofertilizers into soil at regular intervals with organic matter is crucial for sustainability reasons, since it helps to maintain healthy, rich soil (Koopmans and Goldstein 2001) [26].

One of the most important cereal crops, wheat (*Triticum aestivum* L.) provides almost 20% of the calories consumed by the entire human population (Reynolds *et al.*, 2011) [39]. About two-thirds of India's population relies on wheat as a main source of nutrition. Chapatti and bakery goods are just a few examples of the many ways it is consumed. It flourishes in all agroclimatic zones and provides food security to India. Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Gujrat, and Rajasthan comprise over 90% of the wheat-growing region. The Rabi season (2018-2019) saw a record productivity of 34.24 q/ha and a harvest of 101.20 million tonnes from an area of 29.55 million hectares (ICAR-IIWBR, 2019).

According to Shivay (2007), nitrogen is the most important ingredient for plants to operate properly. Nitrate pollution is on the rise, despite the fact that nitrogen is the most critical

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macronutrient for wheat yield optimisation. Consequently, there is a pressing need to find ways to lessen nitrate contamination without sacrificing agricultural productivity (Ramesh *et al.*, 2005)^[37]. According to Sharma *et al.* (2012)^[44], *Azospirillum* sp. is responsible for nitrogen fixation, while *Rhizobium* sp. is utilised as a plant growth promoter (PGR) in wheat.

In live plant cells, phosphorus is an essential mineral that is involved in many activities, including respiration, photosynthesis, energy storage, transformation, and more (Yasmin and Bano, 2011; Solangi *et al.*, 2016)^[54, 47]. Several types of Plant Growth Promoting *Rhizobium* (PGPR) bacteria, including *Enterobacter*, *Bacillus*, *Azospirillum*, and *Pseudomonas*, are responsible for phosphorus solubilisation (Goes *et al.*, 2012; Mehnaz *et al.*, 2010; Tahir *et al.*, 2013)^[48, 28, 49]. By producing organic acids such as acetic acid, malic acid, citric acid, and oxalic acid, these fungi transform the mineral phosphate into soluble phosphates (primary and secondary orthophosphates) (Vessey *et al.*, 2004; Tahir *et al.*, 2013; Solangi *et al.*, 2016)^[51, 49]. To further improve nutrient use efficiency and harvest yield, biofertilizers can be used with inorganic fertilisers. *Rhizobium*, *Pseudomonas*, *Azotobacter*, *Azospirillum*, *Bacillus*, *Burkholderia*, *Klebsiella*, and *Enterobacter* are among the many bacterial species that have been found to stimulate plant development (Bashan *et al.*, 2004). Important in organic farming, biofertilizers can increase yields by incorporating atmospheric nitrogen into soil, solubilising soil phosphorus, or stimulating plant development via the production of chemicals that promote this process (Ram *et al.*, 2014)^[36]. The microbes found in biofertilizers work to replenish the soil's organic matter and return it to its natural nutrition cycle. Biofertilizers not only improve soil sustainability, but they also allow for the production of healthy, high-quality plants. Soil fertility, plant nutrition, and crop yield can all be improved with the use of biofertilizers (Bohme and Bohme, 2006; Jalili *et al.*, 2009; Abedi *et al.*, 2010; Medani and Taha, 2015)^[14, 23, 3, 27]. This study's overarching goal is to learn how biofertilizers influence wheat yield and growth while simultaneously considering their environmental impact and the state of the soil.

Effect of *Azotobacter* on wheat: Grain and straw yield, as well as yield-related metrics such as plant height, tiller density, leaf dry weight, leaf area index, and so on, were all maximised after applying *Azotobacter chroococcum* with humic acid. The dehydrogenase and phosphatase activities in the wheat rhizosphere were found to be significantly enhanced after the introduction of arbuscular mycorrhiza (*Glomus mosseae*) and *Azotobacter chroococcum*. The availability of macronutrients (N, P, and K) and some micronutrients (Fe and Zn) is enhanced when wheat seeds are inoculated with humic acid or isolated from *Azotobacter chroococcum* or arbuscular mycorrhiza (Abou-Aley *et al.*, 2009)^[4]. According to Ahmed *et al.* (2011)^[9], when wheat is inoculated with yeast and *Azotobacter*, the following traits are most pronounced: longest spikes, most spikes per square metre, and maximum dry weight of shoot and flag leaf area. When comparing treated and untreated wheat plots, researchers discovered that the former showed significantly higher plant height, tiller count, and dry matter accumulation. Plots treated with *Azotobacter* had the highest yield attribution features compared to those without inoculation, including grain weight per plant, spike length, and weight of 1000 grains. According to Singh *et al.* (2013)^[46], the plots that were inoculated with *Azotobacter* had the highest yield. Out of all the biofertilizer treatments, the *Azotobacter* plots had the highest amounts of proline and soluble sugar content. Seeded with

Azotobacter and nano Zn-Fe oxide, the wheat plots produced the most harvest. According to Sharifi *et al.* (2020)^[43], the maximum concentrations of carotenoids and chlorophyll are achieved when *Azotobacter* is combined with nano Zn-Fe oxide. When wheat seeds are infected with *Azotobacter* + green manure + FYM, the results show the highest nutrient uptake, grain quality, protein content, and production. However, *Azotobacter* + green manure is the only combination that yields the highest net return (Ram *et al.*, 2014)^[36]. Research has shown that treating wheat seedlings with *Azotobacter* results in the maximum grain production. An increase in crop dry matter can be achieved with *Azotobacter* inoculation as well (Patra and Singh, 2018)^[46].

Effect of *Azospirillum* on wheat: Wheat yields are increased when humic acid and *Azospirillum braselence* are applied together. as humic acid and *Azospirillum braselence* are applied together, the soil's electrical conductivity (EC) drops and its pH goes down. This is because as microbes break down organic materials, they release organic acids, which reduce the soil's pH. Humic acid and *Azospirillum braselence*, when applied together, produce the greatest concentrations of the accessible macronutrients potassium, nitrogen, and phosphorus as well as the micronutrients iron, manganese, and zinc. Humic acid and *Azospirillum braselence*, when applied together, increase the wheat plant's nutritional concentration (both macro and micronutrients) (Alakhdar *et al.*, 2020)^[10]. Increased wheat grain production is achieved by combining *Azospirillum* with 45 kg/ha of nitrogen and 5 kg/ha of phosphorus. Amanullah *et al.* (2012)^[11] found that using a mix of biofertilizer and inorganic fertilisers increased the fresh biomass output, 1000 seed weight, and tillers per square metre. Plots treated with *Azospirillum* had the greatest nitrogen uptake by plants compared to other treatments and the control (Singh *et al.*, 2013)^[46]. Plants that had their seeds injected with *Azospirillum* also showed the highest efficiency of the photosystem Δ (PS- Δ). *Azospirillum* is also home to the most active catalase (CAT) enzyme. According to Namvar and Khandan (2013)^[31], when wheat seeds are treated with *Azospirillum*, the following characteristics are enhanced: maximum plant height, number of spikes per plant, number of grains per spike, weight of 1000 grains, straw yield, grain yield, and protein content. According to Mohammed *et al.* (2012)^[29], when chicken manure, *Azospirillum braselence*, and *Bacillus polymyxa* are applied to wheat plants, the outcomes include the highest plant height, reproductive tiller number, grain per main head, and seed per plant.

Effect of Phosphate Solubilising Bacteria on wheat: The most effective way to increase wheat yield and improve yield qualities is to treat the plants with the required dose of fertilisers (RDF) plus phosphorus, potassium, and vermicompost at a rate of 1 tonne per hectare. According to Devi *et al.* (2011)^[15], the soil's accessible nitrogen, phosphorus, and potassium levels were also elevated as a consequence of this treatment. Inoculating wheat plants with PSB also influences their roots; compared to non-inoculated treatments, inoculated treatments show an increase in root biomass and diameter. In the presence of sufficient phosphorus in the root zone, PSB promotes an increase in root length, volume, and surface area. Root and shoot physiology are both improved by PSB because it increases root phosphatase activity.

The inoculation of PSB resulted in an increase in both mineral accumulation and chlorophyll content (Elhaissofi *et al.*, 2020)^[17]. Root dry biomass, shoot height, and dry matter are all

greatly enhanced by inoculating plants with PSB in addition to rock phosphate. The grains, roots, and shoots are able to absorb more phosphorus when treated with PSB+ rock phosphate. According to Kaur and Reddy (2015) ^[21], the PSB+ rock phosphate treatment also results in a high level of available P. The PSB's activity is stimulated by raw phosphate, leading to an increase in enzyme activity and soil respiration. The effects of the enhanced plant development, as measured by plant dry weight, number of tillers per plant, nutrient status, and yield, were made evident by the rise in soil enzyme activity (Namli *et al.*, 2017) ^[30]. Patel *et al.* (2014) ^[33] found that increasing the application of 40 kg P₂O₅ + PSB + 40 kg sulphur per hectare increased grain and straw yield. Plants' morphological and physiological traits, such as root and shoot dry weight, CAD, SOD, and POD enzyme activity, and total absorption of P, K, and Si, are enhanced by the triple interaction of PSB in its soluble form with Si and P (Rezakhani *et al.*, 2019) ^[40]. Wheat plants benefit from the application of PSB strain B. Cepacia BAM-6 because of the synergistic interaction between the PSB and Arbuscular Mycorrhizal Fungus (AMF). According to Saxena *et al.* (2014) ^[41], the combination of B. cepacia BAM-6 and AMF improves seed germination%, leaf area, root and shoot length and dry weight, and wheat production. According to Schoebitz *et al.* (2013) ^[42], after 60 days of growth, the wheat plant reaches its maximal phosphorus uptake when applied PSB (*P. fluorescens*) + 3.25 ppm of P. Uleman *et al.* (2018) found that compared to the un-inoculated plots, seeds treated with PSB exhibited a better germination percentage and seedling vigour. Wheat dry matter content, plant height, spike length, number of grains per spike, and yield are all enhanced by combining PSB with AMF (Yousefi *et al.*, 2011) ^[55].

Conclusion

Bio-fertilizers can be proving a great replacement to the chemical fertilizers because these are easily available, cost effective and can be used over a large area through seed inoculation. As we know that soil health and environment is at risk due to excessive use of the chemical fertilizers. The food that we consume is not healthy because the soil in which it grows is not healthy due over use of the chemical fertilizers. So, to maintain the soil and human health bio-fertilizers can be a great ally.

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